SUPPORT FOR THE AMENDMENT

This Amendment cancels Claims 2-4, 6-8 and 10-11; amends Claims 1, 5, 9 and 12-14; and adds new Claims 15-24. Support for the amendments is found in the specification and claims as originally filed. In particular, support for Claims 1 and 5 is found in canceled Claims 2 and 6, respectively, and in the specification at least at page 11, lines 8-9 ("the treatment with active oxygen species is normally conducted at a temperature of 300°C to 650°C"). Support for Claim 9 is found in canceled Claims 10-11 and in the specification at least at page 15, lines 8-9 ("the second annealing treatment is conducted preferably at a temperature of 630 to 750°C"). Support for new Claims 15, 17, 19 and 24 is found in the specification at least at page 10, line 20 to page 11, line 4. Support for new Claims 16, 18 and 22 is found in the specification at least at page 11, line 10. Support for new Claim 20 is found in original Claims 9-10 and in the specification at least at page 11, lines 8-9 and page 14, lines 17-23. Support for new Claim 21 is found in original Claim 12. Support for new Claim 23 is found in original Claim 9. No new matter would be introduced by entry of these amendments.

Upon entry of these amendments, Claims 1, 5, 9 and 12-24 will be pending in this application. Claims 1, 5, 9 and 20 are independent.

REQUEST FOR RECONSIDERATION

Applicants respectfully request entry of the foregoing and reexamination and reconsideration of the application, as amended, in light of the remarks that follow.

Applicants thank the Examiner for the courtesies extended to their representative during the January 29, 2003 personal interview.

As discussed at the interview, the present invention is directed to a method of manufacturing a capacitor containing a vapor-deposited tantalum oxide film. Vapor-deposited tantalum oxide is amorphous, and subsequent annealing to form Ta_2O_5 typically results in loss of oxygen from the tantalum oxide and undesirable oxidation of the underlying substrate, both of which lead to inferior dielectric characteristics. However, according to the present invention, vapor-phase deposited tantalum oxide is treated with active oxygen species and annealed at a temperature below the crystallization temperature of the tantalum oxide in an inert atmosphere to produce a high quality Ta_2O_5 insulator with a high dielectric constant.

Claims 1-2 and 5-6 are rejected under 35 U.S.C. § 103(a) over U.S. Patent No. 5,352,623 ("Kamiyama") in combination with U.S. Patent No. 5,468,687 ("Carl"). In addition, Claims 9-11 and 14 are rejected under 35 U.S.C. § 103(a) over Kamiyama and Carl and further in view of U.S. Patent No. 4,851,370 ("Doklan"). Furthermore, Claims 3-4, 7-8 and 12-13 are rejected under 35 U.S.C. § 103(a) over Kamiyama, Carl, and Doklan, and further in view of U.S. Patent No. 5,521,423 ("Shinriki").

Kamiyama discloses a capacitor including a thin film of tantalum oxide is formed by vapor depositing tantalum oxide on a polysilicon substrate and then densifying and nitriding the tantalum oxide film. Kamiyama at Abstract; column 4, lines 16-18.

Kamiyama only discloses a method of forming a capacitor of an MIS structure having poly-Si as a lower electrode. After the natural oxide on the poly-Si is removed, the surface of the poly-Si film is subjected to rapid thermal nitriding at 800 to 1100°C, using ammonia gas. Then, a tantalum oxide film is formed on the poly-Si film. The tantalum oxide film is then densified at 600 to 1000°C by a thermal treatment in an oxidizing atmosphere, and then nitrided at room temperature to 500°C by a plasma treatment with ammonia. See, e.g., Kamiyama at column 4, line 4 to column 5, line 4, including the disclosure that:

> [T]he tantalum oxide film 11 is densified by a thermal treatment ***in an oxidizing atmosphere*** using an electric furnace, then nitrided by a plasma treatment with ammonia by use of a plasma-ion generator. During the nitriding, a tantalum nitride-oxide film (TaO_xN_y) is formed on the surface of the tantalum oxide film. The densifying step is preferably conducted at 600°C to 1000°C for 5 minutes to 5 hours. The densifying step may be effectively performed by use of electric furnace, a lamp-heater, plasma-ion generator, or a combination thereof. The densifying step may be conducted by use of nitrous oxide (N_2O) as the treatment gas. The nitriding step by plasma treatment is preferably conducted at a temperature ranging from ***a room temperature to 500 °C*** under pressure ranging from 0.1 to 10 Torr, and with the electric power ranging from 50 to 500 W. The nitriding step may be conducted by use of a pure nitrogen gas in place of ammonia. Kamiyama at column 4, line 54 to column 5, line 4 (emphasis added).

However, Kamiyama fails to suggest the limitation of independent Claims 1, 5, 9 and 20 of ***annealing*** a tantalum oxide film at a temperature of ***620 to 690 °C***, which temperature is lower than a crystallization temperature of tantalum oxide, ***in an inert atmosphere.***

In Kamiyama, the surface of the poly-Si lower electrode is nitrided to silicon nitride. Therefore, even when the tantalum oxide film formed on the nitrided poly-Si electrode is heat-treated at 600 to 1000°C in an oxidizing atmosphere, the poly-Si electrode is not oxidized since the nitride film acts as a barrier film against the diffusion of oxygen.

However, since the capacitor of the present invention is of an MIM structure having a metal film, i.e., a ruthenium film, as a lower electrode, oxygen diffuses through the tantalum oxide film and oxidizes the metal film when the tantalum oxide film is thermally treated at 600 to 1000°C, and thus the lead-current increases (see curve b in the specification at FIG. 4). By annealing the tantalum oxide film at a temperature of 620 to 690°C, which temperature is lower than a crystallization temperature of tantalum oxide, in an inert atmosphere, oxygen in the tantalum oxide film does not diffuse into the ruthenium electrode to oxidize the ruthenium electrode, providing a tantalum oxide film having a sufficient dielectric constant.

The secondary references fail to remedy the deficiencies of Kamiyama.

Carl discloses annealing Ta_2O_5 thin films in an ozone enhanced plasma. Carl at Abstract. Like Kamiyama, Carl only discloses a method of forming a capacitor of an MIS structure having poly-Si as a lower electrode. An n- or p-type silicon substrate is nitrided, and a tantalum oxide film is formed thereon, which is then plasma-annealed in an atmosphere of ozone and oxygen gas at a temperature of 400°C.

Doklan discloses annealing in a mixture of oxygen and nitrogen. Doklan at column 4, lines 18-25.

Shinriki discloses forming tantalum oxide by thermally decomposing $Ta(OC_2H_5)_5$ at a substrate temperature of 400°C under a reduced pressure of 1 Torr in an oxygen atmosphere. Shinriki at column 5, lines 3-7. Shinriki only discloses an antifuse structure including metal wiring. The lower electrically conductive material mentioned in Shinriki at column 2, lines 50-61, is a material for wiring, and not for an electrode. Shinriki does not disclose a capacitor structure at all.

Because the cited prior art fails to suggest the limitation of independent Claims 1, 5, 9 and 20 of ***annealing*** a tantalum oxide film at a temperature of ***620 to 690 °C***, which temperature is lower than a crystallization temperature of tantalum oxide, ***in an inert atmosphere***, the rejections under 35 U.S.C. § 103(a) should be withdrawn.

Claims 1, 3-5, 7-9 and 12-14 are rejected under 35 U.S.C. § 112, second paragraph, because assertedly the limitation "crystallization temperature of tantalum oxide" is indefinite. To obviate the rejection, the claims are amended.

In view of the foregoing amendments and remarks, Applicants respectfully submit that the application is in condition for allowance. Applicants respectfully request favorable consideration and prompt allowance of the application.

Should the Examiner believe that anything further is necessary in order to place the application in even better condition for allowance, the Examiner is invited to contact Applicants' undersigned attorney at the telephone number listed below.

Respectfully submitted,

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